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Contracting on Fertility:
A Model of Marriage in Africa

1. Introduction

Marriage payments are widespread in Sub-Saharan Africa. The payments consist of bride price (or bride wealth) rather than dowry: a payment from the groom, or the groom's family, to the family of the bride. Although bride wealth is widespread, there is quite a bit of variation across and within ethnic groups, as well as over time, in the size and type of payments made.

In Southern and Eastern Africa, many Bantu groups traditionally use cattle to make marriage payments. Moreover, contracts are often (completely or partially) structured around fertility. The size, and sometimes also the timing, of the payments are linked directly to the birth of children.[1] In addition, although the parties agree on a contract prior to marriage, after an initial payment, other installments are often paid over a long period of time. Modeling marriage payments in a contract theory framework allows me to address the following questions: (1) Why are marriage contracts structured in this way? (2) What is the relationship between the structure of the contract and fertility?

The motivation for this topic comes from my experience in Meatu District, Tanzania. The picture that emerged from conversations and interviews was very different from my understanding of the "conventional" explanations of bride wealth (and dowry), which relate payments to the role of women in existing economic structures and the value of their labor[2]. As argued by Boserup (1970), in societies where women do most of the

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[1] Comaroff (1980), Krige and Comaroff (1981)
[2] Boserup (1970)

agricultural work, bridewealth compensates her family for the loss of her future labor, while the inverse is true of dowry[3].

Implicit in the marriage contract are a number of rights and obligations, including rights over a woman's productive labor. However, the contract is explicitly linked only to fertility. The first insight from contract theory (perhaps insight is too strong a word) is that a contract must be structured around variables that are both observable and verifiable. The birth of a child is observable in a way that labor effort and marital fidelity are not.

Although the birth of a child is easily observable, there is uncertainty about a couple's fertility (in this context usually attributed to the woman). Prior to the marriage, neither the bride nor the groom's families have information about future fertility. More importantly, even after the birth of a child, a third party (such as a court of law) may not be able to judge a woman's fertility level, since the couple has private information not available to the courts (e.g., contraception use, frequency of sexual relations, etc). In the contract theory literature, this is known as *nonverifiability*.

> "When two parties engage in a relationship, it is often the case that they are uncertain about the value of some parameter that will affect their future gains from trade…the trading partners cannot write *ex-ante* contracts contingent on the state of nature, because this state of nature is not verifiable by a third party, a benevolent court of law, that could enforce their contract."[4]

The model below characterizes an incentive compatible contract in the presence of relationship specific investments, and nonverifiability of the state of nature. In this case, the groom's family is the principal. They make a transfer to the bride's family (rather, her father) as a payment for the "production" of children. In addition, the contract can provide full insurance to a risk-averse principal.

2. Theoretical Framework

2.1 Basic Setup

We make the following standard assumptions:

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[3] However, others have explicitly linked bridewealth to the production of children. For example, writing about marriage in Southern Africa, Kuper (1982) links bridewealth to a woman's reproductive labor.

[4] Laffont and Mortimer (2002), p. 240

- Fully rational individualistic agents: both are optimizers and maximize individual utility.
- The agent and principal are risk neutral.[5]
- There is a legal framework in which the contract takes places, including a costless and benevolent enforcer (such as a court of law).

In addition, we assume:

- Neither the agent nor the principal know the state of nature at the time of the contract.
- The state of nature is not verifiable by a third party.

The groom's family is interested in acquiring children. The number of children is given by k, and the value to the groom's family of these children is given by F(k), where $F(0)=0$, $F'(.) > 0$, and $F''(.) <0$.[6] There is both a fixed cost of producing children, M, and a marginal cost θ, in the set $\Theta = \{\theta_H, \theta_L\}$. The marginal cost of production reflects the underlying fertility of the couple. The probability that the bride[7] has high fertility, and therefore low marginal cost of production, θ_L, is p, and the probability of θ_H is $(1-p)$. The costs of children are given by:

(1) $C(k, \theta_L) = M + \theta_L k$ with probability p

(2) $C(k, \theta_H) = M + \theta_H k$ with probability $(1-p)$

The contracting variables are the number of children k, and the transfer t received by the bride's father. Both the number of children and the transfer are observable and verifiable by a third party. We normalize $M = 0$.

The timing of the contract is as follows: At t=0, neither the principal nor the agent know the state of nature. The principal offers the agent a menu of options. At t=1, the agent accepts or refuses the menu. At t=2, both principal and agent learn about the state of nature, θ in $\{\theta_H, \theta_L\}$. At t=3, the agent chooses an element of the menu.

The fact that the bride-price is only partially paid at the start is critical to this application of contract theory. The idea is that the payment of an initial amount and

[5] If we relax the assumption of risk neutrality of the principal, the results are unchanged. However, this is not the case for risk neutrality of the agent.

[6] These assumptions seem reasonable in a context of abundance of land and scarcity of labor, and widespread fostering of children.

[7] I will refer to the fertility of the bride, since it is usually attributed to the woman in this context.

subsequent installments effectively constitutes a list or menu. That is, subsequent payments may not be demanded by the bride's father depending on the state of nature.[8]

The groom (principal) maximizes expected utility:

(3) $\text{Max } E(V) = p(F(k_L) - t_L) + (1-p)(F(k_H) - t_H)$

$\{(k_L,t_L), (k_H,t_H)\}$

Subject to the following incentive compatibility constraints:

(4) $t_L - \theta_L k_L >= t_H - \theta_L k_H$

(5) $t_H - \theta_H k_H >= t_L - \theta_H k_L$

Since the (risk-neutral) agent does not know the underlying fertility of the bride, the participation constraint is now that *expected* benefits are above some reservation utility:

(6) $p(t_L - \theta_L k_L) + (1-p)(t_H - \theta_H k_H) >= U_R$

Where U_R is the reservation utility level of the agents. We can rewrite the principal's expected utility in terms of the information rents U_H and U_L, defined as follows:

$U_H = t_H - \theta_H k_H$,

$U_L = t_L - \theta_L k_L$.

(7) $\text{Max } E(V) = p(F(k_L) - \theta_L k_L) + (1-p)(F(k_H) - \theta_H k_H) - (p\, U_L + (1-p)\, U_H)$

$\{(k_L,U_L), (k_H,U_H)\}$ subject to:

(8) $U_L >= U_H + (\theta_H - \theta_L)\, k_H$

(9) $U_H >= U_L - (\theta_H - \theta_L)\, k_L$

(10) $(p\, U_L + (1-p)\, U_H) >= U_R$

Since (10) enters utility negatively, optimizing implies the constraint is binding. Substituting into (7), it is easy to see that $F'(k_L^*) = \theta_L$ and $F'(k_H^*) = \theta_H$, equivalent to full information. Values of U_L^* and U_H^* that satisfy the constraints are given by:

(11) $U_L^* = U_R + (1-p)(\theta_H - \theta_L)k_H^*$, and

(12) $U_H^* = U_R - p\,(\theta_H - \theta_L)k_H^*$

Recall, by definition $U_i^* = t_i^* - \theta_i k_i^*$ for i = L, H. Substituting we find $t_L^* > t_H^*$.

2.2 Risk Aversion of the Principal

[8] If we modeled this as repeated interactions rather than a single one, the principal and agent could bargain over the subsequent payments (rather than have it be the agent choosing an element of the menu).

If the principal is risk averse, the agent's rents must satisfy the following additional conditions:

(13) $F(k_L^*) - \theta_L k_L^* - U_L^* = F(k_H^*) - \theta_H k_H^* - U_H^*$ (full insurance)

(14) $pU_L^* + (1-p)\, U_H^* = U_R$ (agent's participation constraint)

Solving, we get:

(15) $U_L^* = U_R + (1-p)\,(F(k_L^*) - \theta_L k_L^* - F(k_H^*) + \theta_H k_H^*)$

(16) $U_H^* = U_R - p\,(F(k_L^*) - \theta_L k_L^* - F(k_H^*) + \theta_H k_H^*)$

We can check that these information rents satisfy the ICC of both types. Rearranging (13), we have:

(17) $U_L^* - U_H^* = F(k_L^*) - \theta_L k_L^* - F(k_H^*) + \theta_H k_H^*$,

If $F(k_L^*) - \theta_L k_L^* - F(k_H^*) + \theta_H k_H^* > (\theta_H - \theta_L) k_H^*$, then (8) is satisfied.

$F(k_L^*) - \theta_L k_L^* + \theta_H k_H^* > F(k_H^*) + \theta_H k_H^* - \theta_L k_H^*$

$F(k_L^*) - \theta_L k_L^* > F(k_H^*) - \theta_L k_H^*$, holds by definition of k_H^*

Similarly,

(18) $U_H^* - U_L^* = F(k_H^*) - \theta_H k_H^* - F(k_L^*) + \theta_L k_L^*$, and if

$F(k_H^*) - \theta_H k_H^* - F(k_L^*) + \theta_L k_L^* > -(\theta_H - \theta_L) k_L^*$, then (9) is satisfied.

$F(k_H^*) - \theta_H k_H^* + \theta_L k_L^* > F(k_L^*) - \theta_H k_L^* + \theta_L k_L^*$,

$F(k_H^*) - \theta_H k_H^* > F(k_L^*) - \theta_H k_L^*$, holds by definition of k_H^*

Therefore, with a risk averse principal, an *ex-ante* contract still allows for implementation of the first best outcome.

2.3 Other extensions

- Add informative (ex-post) signal that can be taken into account by courts. For example, the timing to first birth may be an informative signal about underlying fertility.
- An informative (ex-ante) signal that can be taken into account by the agent (e.g., mother's fertility, height-to-weight).
- Model it as repeated rather than one-shot interaction. Prior payments and realizations can be taken into account. The principal and agent would agree on a list of possible contracts, then bargain over payments.
- Timing of additional payments as insurance
- Mutual insurance

3. Data Sources

3.1 Tanzania Living Standards Survey

The data used here was collected in Meatu District, Tanzania, as part of the Tanzania Living Standards Survey (2001/2002). In addition to the household and community surveys carried out in 2002, a third questionnaire (the "Family Survey") was administered to roughly 250 households (about a fifth of all households surveyed). The Family Survey contained questions on marriage and fertility, and was administered to one woman per household. Among other things, women interviewed were asked whether their current husband had paid bride wealth, and if so, the size of the payment in cash or kind.

The sample consists almost exclusively of Sukuma households. The Sukuma, a Bantu group from the Northwest of Tanzania, are the largest ethnic group in the District. Bridewealth is generally paid in kind, using cattle. Residence after marriage is with the husband's family. Roughly a third of all women marry someone in the same village they resided prior to marriage.

Table 1 presents some descriptive statistics. Although 16 percent of women report their families did not receive bridewealth for their current marriage, all but four of these women have been married before. It is very likely their families received bridewealth at the time of their first marriage, though the data is not available.

Consider a model where fertility depends on both demographic, sociological characteristics and financial incentives: $TF = f(X, BP, u)$. Total fertility, F, is a function of X demographic and sociological characteristics, transfer or payment BP, and an error term u. We can estimate a model $TF = X\beta + \alpha BP + u$ (as in Table 1), or with data on the timing and size of payments, we can estimate a model of differences.

Table 2 presents estimates for (1) a regression model with bridewealth (BP) as the dependent variable and (2) a regression with number of births (TF) as the dependent variable, and bridewealth (BP) as one of the explanatory variables. The positive correlation between bride price and total births is consistent with the model presented above, but does not rule out alternative models.

Table 1: Descriptive Statistics

Variable	Mean	Std. Deviation	Obs
Female age	33.2	12.2	250
Female education	3.6	3.4	247
Male Age	39.9	13.6	214
Male education	4.5	3.3	240
Family received bridewealth	0.84	0.36	250
# of cattle paid as bridewealth	12.4	8.67	220
Total births	5.02	3.29	250
Woman married before	0.17	0.38	250
Woman in polygynous marriage	0.11	0.32	250

Source: Meatu Family Survey, 2002

Figure 1: Bride Price Payments

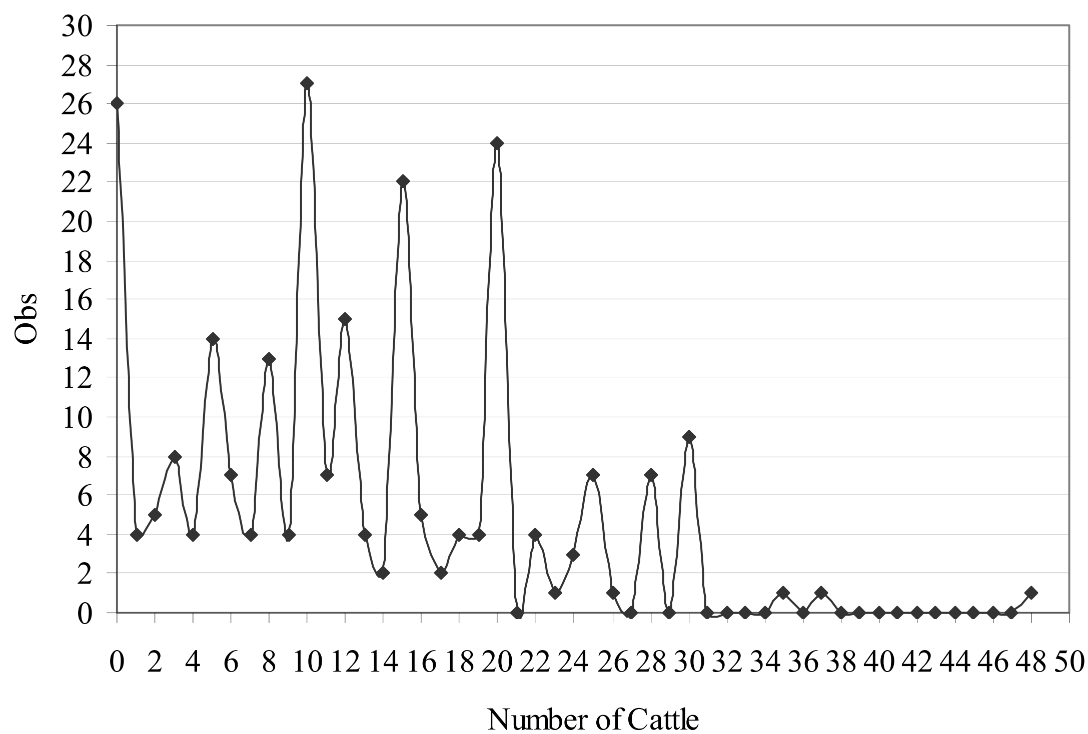

Table 2: Bridewealth and fertility

	Dependent variable				
	Number of cattle paid as bridewealth		Number of births to woman		
Number of cattle paid as bridewealth	--	--	--	0.06	0.06
				(0.03)**	(0.03)**
Female age	-0.04	-0.03	0.06	0.07	0.04
	(0.09)	(0.07)	(0.03)**	(0.03)**	(0.02)
Female education	-0.42	-0.45	-0.12	-0.10	-0.06
	(0.21)**	(0.22)**	(0.07)*	(0.06)	(0.06)
Years married	0.17	0.16	0.11	0.10	0.08
	(0.11)*	(0.11)	(0.03)***	(0.03)***	(0.03)***
Woman was married before	-7.56	-8.02	-0.23	0.22	0.14
	(1.37)***	(1.54)***	(0.57)	(0.58)	(0.70)
Woman in polygynous marriage	--	--	0.34	0.30	0.60
			(0.53)	(0.52)	(0.55)
Number of cattle owned at time of survey (2002)	0.19	0.18	0.03	0.02	0.00
	(0.04)***	(0.05)***	(0.01)**	(0.02)**	(0.01)
Other asset controls	YES	YES	YES	YES	YES
Male Age, Education	NO	YES	NO	NO	YES
R-squared	0.33	0.31	0.50	0.48	0.52
Observations	208	183	208	208	183

Notes: Robust standard errors clustered at the village level. Source: Meatu Family Survey 2002.

3.2 Additional data sources

- 1996 Uganda DHS: Cross-section; representative sample of two districts. Includes information on: size and composition (cash, livestock) of bridewealth, detailed fertility and marriage history for women, mother's fertility, fertility preferences.
- 1995 Ethiopian Rural Household Survey: Cross- sectional data. Includes information on the type of transfer at marriage (cash, livestock, land, etc), an estimate of it's current value, and whether the respondent can transfer or sell the assets.

4. Issues I would like to discuss

The main problem has to do with the lack of empirical content of the models, and/or the absence of sufficiently detailed empirical information to control for endogenous contract selection. The Uganda DHS and Ethiopia data may be helpful in this respect.

Does this model resonate with you? Is nonverifiability a problem? If not, maybe it would make more sense to model this as a form of insurance, and test empirically for it. Would it be useful to contrast the structure of marriage contracts across groups (rather than model within-group variation, as I have done here)?

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